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Ecology and Resource Development in Southeast Asia

A REPORT TO THE FORD FOUNDATION

ECOLOGY AND RESOURCE DEVELOPMENT IN SOUTHEAST ASIA

Gordon Conway
Jeff Romm

The Ford Foundation
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Mr. Conway is with the Environmental Resource Management Research Unit, Imperial College of Science and Technology, Silwood Park, Ascot, Berkshire, England.

Mr. Romm is with the Southeast Asia Office of the Ford Foundation, Bangkok, Thailand.

August 1973

CONTENTS

I. Introduction.. 1

II. Environmental Issues in Southeast Asia.............. 5
  Shifting Cultivation.............................. 5
  Timber Extraction................................. 8
  Water Use... 9
  Freshwater Fisheries.............................. 11
  Multiple Use of Water Resources................... 13
  Land Use Planning................................. 15
  Forestry.. 15
  New Cereal Varieties.............................. 19
  Pests... 20
  Multiple Cropping................................. 23
  Urban Development................................. 25
  Marine Resources.................................. 30

III. The Context of Choice in Resource Development....... 32
  Economic Development.............................. 32
  Government.. 33
  Tradition and Perceptions of Nature............... 34
  Population.. 36
  Urbanization...................................... 37
  Nationhood.. 37
  International Position............................ 38

IV. Organization and Innovation for Progressive Resource Development........................... 40
  Regional Development Perspectives................. 41
    The Frontier Region............................ 41
    The River Basin................................ 44
    The Urban Region............................... 48
  Multiple Use of an Ecosystem...................... 51
    Reservoirs..................................... 53
    Uplands.. 55
    Cities... 57
  Population, Science, and Resource Policies....... 62
  Environmental Law................................. 64
  Public Education.................................. 68
  Professional Coordination and Communication...... 70
  Some Innovative Programs.......................... 72
    Terrestrial Ecology and Resource Management... 72
    Centers of Research and Training.............. 73
      Bogor, Indonesia........................... 73
      The University of Malaya Ecology Unit...... 75

The Kasetsart University School of Forestry. 76
University of the Philippines, Los Banos Campus.............................. 76
Multiple Cropping: Chiengmai University and the International Rice Research Institute. 77
Pest Ecology...................................... 78
Marine Ecology and Resource Management........... 79
Waste Utilization Technology...................... 80
Information....................................... 82

I. INTRODUCTION

"Ecology" and "environment" have become emotionally charged slogans in recent years. Public alarm in industrialized countries about environmental quality has led to the emergence of a new social movement, with suitable villains, heroes, and crusades. These heretofore staid technical concepts have become ambiguous and, in some quarters at least, almost fighting words.

Our usage is more mundane. Ecology, as a quantitative science, is relatively youthful. As a collection of knowledge, however, it is as old as man's curiosity about his environment. The environment of any organism is the collection of other organisms and chemical and physical elements with which the organism interacts. An ecosystem is any relatively self-contained system of organisms and their environment. Ecology is the study of ecosystems: their structure, functioning, and changes. Ecologists explore interactions between organisms and their environments.

Any natural regime of soil, water, atmosphere, and light has some maximum amount of living material, or biomass, that it can support. If left undisturbed, biotic communities evolve toward successively more complex patterns of organization that increase the biomass. Those species better able to utilize site resources gradually replace those less efficient.

Natural ecosystems can stabilize themselves in response to external disruptions. This ability is greatest when the structure of a system is most complex. Natural ecosystems also tend to disperse their converted energies into unexploitable forms. The more complex the system, the higher the proportion of its biomass that cannot be appropriated for human use. When men manipulate an ecosystem for their own purposes, they attempt to direct its natural productive potentials into exploitable forms. By so doing, they simplify the system and reduce its natural capacities for self-stabilization. The "balance of nature" is altered. Unless men understand the effects of their actions on natural stabilizing mechanisms and provide adequate compensations, the stability of the system may be disrupted, its structure disintegrate, and its productive capacity spiral into irreversible decline.

Southeast Asia offers many examples of problems arising from manipulation of ecosystems. Intensified shifting cultivation and excessive rates of timber extraction are denuding upland slopes, accelerating soil erosion, weakening natural controls of water flow, and exacerbating floods and siltation in lowland areas. The absence of suitable management jeopardizes future forest yields and water control throughout the region. Water-resource projects can destroy fisheries, cause salinization of agricultural soils, and spread disease. The usefulness of river impoundments has been impaired by ecological reactions that, without better knowledge and planning, may recur on a grander scale in the more ambitious projects of the future.

Modern agricultural techniques increase ecosystem vulnerability to pests and diseases by weakening natural capacities for control. New rice varieties, for example, are susceptible to outbreaks because of their specialized genetic qualities, relatively uniform cultivation patterns, and extensive use. Chemicals can protect crops in the short term but often worsen rather than cure problems and also create new environmental hazards. Cities in the region have difficulties moving goods, people, and ideas; discharging human and industrial wastes; and maintaining a beneficent habitat for occupants. The rich marine resources of Southeast Asia are threatened by urban and industrial development, poor fishing practices, and offshore exploitation of mineral and oil resources. In all these examples, resource development generates consequences that reduce the intended and desired benefits.

Underlying such problems are strong political, economic, and social factors which limit opportunities to find or implement more beneficial methods of environmental use. Economic pressures force Southeast Asian nations to exploit rapidly their natural wealth at the expense of future consequences. Rates of exploitation exceed the regulatory capacities of governmental and traditional institutions. Cultural values discourage the scientific activities and popular attitudes upon which the development of such capacities depends. Population growth, urbanization, the political exigencies of nation-building, and vulnerability to international pressures are other aspects of an inhospitable context for resource management. Indeed, constraints on effective resource management are also those which constrain rates of economic and social progress.

Western nations define their environmental problems from the vantage point of urban, industrialized, affluent societies. In

Southeast Asia, however, people's greatest needs are still basic: adequate food and clothing, a decent place to live, and freedom from serious illness. The challenge to ecology is to find the knowledge to satisfy these needs in ways which are more productive, efficient, and free of undesired effects. Its relevance to development is apparent from its role in crop production and pest control, in forestry and fisheries management, in conservation of water resources, in environmental health and the control of disease, and in urban and industrial planning. Ecological concepts, methods, and skills are essential if people are to obtain the maximum benefits from their environmental resources. They must be developed and employed if human life is to be improved without jeopardy to its sources.

II. ENVIRONMENTAL ISSUES IN SOUTHEAST ASIA

Most ecological problems transcend the traditional and sometimes arbitrary boundaries of academic disciplines. Many problems have arisen because resource users have failed to appreciate the importance and extent of interactions or, in planned development projects, have failed to integrate the specialized disciplines. We will use headings as convenient guides, but will emphasize throughout the relationships among the problems described and among the academic and applied disciplines attempting to cope with them.

Shifting Cultivation

The forests of tropical Southeast Asia are among the richest and most productive in the world. This impression of great natural wealth is deceptive, however, for the productivity depends on a fairly limited and fragile source of nutrients. The tropical forest maintains itself almost entirely on nutrients in the surface layers of the soil. At any given time, a high proportion of the ecosystem's nutrients are bound in its vegetation. Continued soil fertility depends on the return of vegetative detritus to the surface and the assimilation of litter breakdown products by the soil. Unless careful consideration is given to this nutrient cycle when trees are removed, the thin surface layers of soil will lose their fertility and erode, leaving the much poorer subsoil. Crops planted to replace the forest will thrive for a while if the surface layers have been retained but, if the nutrients are not replaced, yields will gradually decline.

The traditional shifting cultivator is aware of this. After felling and clearing the forest, he crops the land for a limited period and then leaves it fallow to restore fertility. The length of the fallow period is critical. To be effective it must exceed some minimum time. Plants invade the fallowed land in a successional pattern. Herbs and grasses establish themselves first, followed by scrub vegetation and, eventually, by secondary forest species. Each stage of the sequence contributes a progressively greater amount of fertility to the surface soil. In Northeast Thailand it takes about ten years to restore the fertility of the land to its pre-cultivation level. If cultivators return in less than ten years, the soil is quickly exhausted and requires much longer than the usual recovery period. When the cycle is reduced to two or three years, crop yields are low and the soil susceptible to erosion. The land can no longer achieve secondary forest cover during the fallow period, and degenerates instead to the coarse, useless *Imperata* grass vegetation.

In North Thailand, between three and four million hectares of watershed forest are subject to shifting cultivation. Over much of this area, the cultivation cycle is short and the land is deteriorating. The problem, directly caused by expanding population, is also common in the Northeast and in the South. High birth rates and heavy immigration have been increasing upland populations by 3.5 per cent or more each year, a rate that doubles population about every twenty years.

Indonesia has a similar problem. Of the nation's 120 million hectares of forestland, approximately 16 million have degenerated to Imperata grassland. Another 14 million are subject to frequent cultivation cycles. The problem is most extreme on Java, where pressure for land has caused replacement of nearly all upland forest cover by Imperata, scrub, or unproductive and almost continuous cropping.

Shifting cultivators in the Philippines, especially on Mindanao, are also in difficult straits. Increases in their numbers, pressures from an aggressive timber industry, and rapid incursions on hillside lands by subsistence farmers have combined to shorten cultivation cycles and induce deterioration. Malaysia has, thus far, escaped the problems of its neighbors. While large areas of the Borneo states are under shifting cultivation, their productive capacities are yet to be endangered by excessively short cycles.

The problems associated with shifting cultivation do not end with declining fertility in upland regions. As vegetative cover is decreased, erosion of surface soils occurs. The residual subsoil loses its capacity to absorb and store rainfall. Water, previously captured for gradual release, washes down slopes, excavating and transporting soil particles. Rivers and streams are unable to contain the periodic rushes of water that now pour through them. Floods become more frequent and severe throughout the region. Recent floods in the North and Central Plains of Thailand caused considerable losses of life, stock, crops, and property. Effects were felt as far downstream as Bangkok. Floods have recently wracked the Philippines and Malaysia. Manila and Kuala Lumpur suffered significant property damage, disruption of services, and confronted the dangers, acute in urban areas, of contaminated water supplies and epidemics of enteric diseases.

Excessive surface runoff from watersheds has other far-reaching implications. Rice cultivation requires a steady release of water during the growing season. The lack of rainfall retention in the soil means that supplies of water to the paddy fields become less reliable. In addition, water runoff from denuded uplands is heavily loaded with silt, which fills lakes and reservoirs, chokes irrigation canals, alters estuaries, coastal swamps, and riverbeds, clogs hydroelectric generation machinery, and diminishes water quality. The resulting damages to agriculture, fisheries, navigation, industry, and municipal services are additional and often unanticipated costs of abuse of distant upland ecosystems.

Timber Extraction

Shortened shifting cultivation cycles result from population pressures on a traditional system. Similar effects are also being created in Southeast Asia by the use of modern exploitative techniques. Logging operations on Kalimantan and Mindanao appear to be a highly mechanized form of shifting cultivation based on an inadequate rotation period. Just as the shifting cultivation cycle in Northern Thailand has been reduced below the safe minimum, so too the current exploitation rates on Kalimantan and Mindanao appear to preclude rotation cycles of length sufficient for maintenance of forest productivity. Moreover, the modern logger lacks an important redeeming quality of the shifting cultivator: he does not possess the intimate environmental knowledge the latter has gained through centuries of experience. Unless properly done, timber extraction can destroy the surface soil, degrade the land, and reduce the production potentials of future forests. Logging companies often lack the knowledge or the will to employ conservation principles. Southeast Asian governments need more information and stronger forestry institutions if they are to enforce adherence to such principles.

Water Use

Problems of water and land use are interdependent. Storage, regulation, and quality of water flows are crucial determinants of land use possibilities in Southeast Asia. Although the region is wetter than most others in the world, its rainfall is not evenly distributed in place or in time. Most parts, especially in the Mekong countries, suffer from prolonged dry seasons which set limits on agricultural potentials. Growing seasons are set by moisture limitations. Because of seasonal water scarcities, only 5 per cent of rice-growing land in South and Southeast Asia is being double-cropped. Even if existing irrigation facilities were fully utilized, this figure could only be increased to 10 per cent. Many modern agricultural technologies, such as those associated with the new high-yield rice varieties, require reliable water supplies and a high degree of water control.

Southeast Asian nations are placing major emphasis on water control systems in their development programs.

Water resource engineering is an advanced technology promising numerous benefits such as irrigation water, flood control, improved navigation, and hydroelectric power. However, its professionals have tended to pay insufficient attention to the interdependent circle of relationships in which their projects must function. Upland and lowland ecological problems commonly arise with the construction of reservoirs, dams, and canals, At times, these unintended and unanticipated negative consequences can outweigh the benefits the projects might generate.

Reservoirs and irrigation canals often fill with silt more rapidly than expected, and power generation machinery is damaged, because inadequate measures have been taken to contain accelerated upland erosion. The result is costly decline in project life. The natural flows of beneficial nutrients to agricultural lands and estuarine fisheries are altered at a cost in productivity or compensatory measures. Dams may block the migratory paths of commercially important species.

Regulation of water flows also reduces seasonal fluctuations in stream discharge rates. Uncontrolled rivers push the sea away from their mouths during seasons of high flow. During seasons of low flow, the sea intrudes upstream. Estuarine and deltaic ecosystems have evolved in relation to these natural cycles of salinity. When streamflows are regulated, these ecosystems are threatened.

These examples suggest the complex ecological character of water use and development. They point to the kinds of information and techniques which must be sought and applied to water development programs if they are to be of maximum benefit.

Freshwater Fisheries

We know little about the ecology of tropical freshwater fish, except for those few species farmed in artificial or semi-natural ponds. This lack of information becomes critical when an environmental adjustment as vast as the Mekong development is implemented. Reliable data about the spawning habits and locations, the annual migrations, and the growth and mortality rates of even the commercially important fish are not available. Migratory habits determine much of the present pattern of fishery in the basin. Construction of dams will probably reduce fish harvests downstream by hindering the migration of fry.

Impoundments can support highly productive fisheries. The reservoir behind the Pa Mong dam, for example, may more than compensate in productivity for the reduction downstream if it is adequately managed for fishery objectives. Proper management requires knowledge of fish ecology, funds for habitat development, and some willingness to compromise the irrigation, hydroelectric, and flood control objectives of the dam. These are not assured for the Pa Mong reservoir, but can be forthcoming in the future.

Freshwater lakes are important sources of livelihood in Southeast Asia. For this reason, they have attracted settlement and have incurred the pressures of intensified use. In the cases of Laguna de Bay near Manila and the Great Lake of Cambodia, fisheries have declined rapidly over the last generation and for reasons which are poorly understood. The deterioration of these major lake resources is a matter of substantial concern. Management measures are being studied, including the construction of barrages to regulate seasonal variations in water and fish movements. As with other forms of water resource, these must encompass the entire lake environment, its shorelands and watersheds, if they are to be effective.

Just as lakes, impoundments, rivers, and the life they support are interdependent parts of a landscape, so too are fish ponds important elements of an agricultural mosaic in Southeast Asia. Ponds are dominant sources of protein in the region and are far from reaching their potential in this respect. Their productivity depends on how they can utilize farm resources and respond and contribute to farming patterns. Thus, Indonesian and Malaysian farm ponds are rapidly declining in productivity because of the destructive effects of agricultural pesticides on fish populations. Vietnamese ponds are highly productive because farmers have learned to fertilize them with human and animal wastes and to stock them with species which complement one another in the pond environment. Malaysian and Philippine researchers have developed high-yielding species for which management plans must now be devised.

Multiple Use of Water Resources

Water resources are complex and their many uses interdependent. Most water development schemes are defined as "multiple purpose projects." This reflects planners' genuine desires to maximize the benefits from resource development projects. Too often, though, it is a cover for doubts that a proposal can be justified economically by its principal objectives alone. Benefits from secondary objectives are "tacked on" because the primary objectives of projects are of questionable economic viability. Meaningful integration of all objectives is seldom seriously attempted. Significant considerations go unnoticed until they emerge as unanticipated and undesirable consequences of the project.

The Nam Phong dam and reservoir system in Northeast Thailand, for example, was constructed primarily for hydroelectricity production, but irrigation, fisheries, flood control, and tourism benefits were also claimed. Few of the expectations for the project have been fulfilled, while many unexpected costs have materialized. Failure of the reservoir to fill as predicted has been a major problem. It seems partly the result of a series of dry years and partly of incomplete or inaccurate hydrological information. Another factor may be the water hyacinth (Eichornia crassipes), which has been allowed to cover extensive areas of the reservoir surface. Evapotranspiration from the hyacinth is more than three times that of open water. The water shortage in the system has caused the reservoir to be managed primarily for power generation at the expense of other objectives. No water has been available for irrigation during the dry season and only limited amounts even in the wet season.

Problems of the Nam Phong project are both ecological and sociological. Flooding the valley behind the dam displaced an agricultural population of approximately 30,000 people. Some of the displaced persons became fishermen on the reservoir, dependent on a fishery far less productive than anticipated. Production is low because of serious imbalances in the reservoir's trophic structure of plankton, herbivorous fish, and carnivores. It could be raised substantially if management programs, based on ecological knowledge, were developed and applied. Other families displaced by the reservoir have moved to poorer soils near its shores. Ironically, considerable effort has gone into drilling for water to provide them with a reasonable basis for crop production. Many families have disappeared from the region.

The small Nam Phong project demonstrates in microcosm problems that, if reproduced by the huge projects proposed elsewhere in the Mekong basin and Southeast Asia, will have far-reaching environmental and social consequences. Blaming the Nam Phong's problems on "mistakes" ignores the fundamental shortcomings that haunt even the best multi-purpose projects. Narrow planning perspectives, inadequate ecological information for water resource development, and inability to manage competitive natural and social needs within a multi-purpose development system, limit productive choices and obtainable benefits from water resource development programs throughout the world.

Land Use Planning

Problems associated with forest exploitation, water and soil conservation, and multiple-purpose water use are familiar. Voices in Indonesia publicly decry the prospect of forest destruction on Kalimantan. Planners in the National Economic Development Board of Thailand and in the Mekong Secretariat are seriously concerned about ecological consequences of the Mekong development programs. The Philippine press demands that the government rehabilitate watersheds and stop predatory logging activities. Nevertheless, such problems are usually viewed in isolation, not seen as integral blends in a total picture of resource use. Just as water resource planners conceptualize a project as a ranked sequence of objectives rather than as a comprehensive alteration of an environment, land use planners focus on specific exploitable opportunities rather than on the interdependencies of an entire landscape. Failure to plan environmental manipulations from an ecosystem perspective will often yield spurious estimates of benefits, costs, and optimal land use patterns. It makes more sense to plan land use to achieve optimal viability of the whole land system rather than to satisfy a checklist of economic and political priorities.

Forestry

Potentially, the natural forests of Southeast Asia can yield timber on a permanent basis. If appropriate silvicultural systems guide timber harvest, continuous yields of desired species can be obtained at the maximum rate that a given site's soil, climate, light conditions, topography, and biotic environment allow. However, sound silvicultural systems are sophisticated ecological instruments. They require extensive knowledge of and experience in specific environments, and their development is necessarily a long, perhaps unending process.

Silvicultural systems take many forms. Some prescribe the clearing of large areas at regular intervals. Their viability depends on the adequacy of the rotation cycle. Cycles must be long enough to allow full regrowth of a forest stand no different in volume, quality, or composition from that removed in the preceding harvest. Other systems may prescribe the removal of individual trees scattered throughout the forest for reasons of maturity, size, vulnerability to diseases and insects, or crown characteristics. They may require the cutting of clusters, patches, or strips. Possible silvicultural systems are as numerous as the infinite variations in forest ecosystems. At one extreme, their effects resemble those of mining or forest destruction. At the other extreme, they seem identical to systems of plantation agriculture. Each is a response to a specific situation. All share one fundamental objective: to create environmental conditions, primarily by cutting trees, that insure perpetuation of the forest in its desired form.

Silviculture is applied ecology. Its systems require comprehensive knowledge of the relationships between forest stands and their environments, the interactions among species and individuals within forest ecosystems, and the effects of human disruptions on site productivity, species composition growth, and forest stability. Answers are not obvious. "Weed" species in the dipterocarp forests, for example, provide shade essential to the survival of tender seedlings of commercial species and are also important components of forest stability and nutrient cycles. Although without commercial value themselves, weeds affect the value of the forest as a whole. The silvicultural unit must be the total forest ecosystem.

The development of silviculture in Southeast Asia is uneven. Silvicultural systems in Southeast Asia are reasonably good for those few kinds of forest that have historically been heavily exploited. They are nonexistent for the many kinds now feeling the intense pressures of population growth and economic development. Because forests regenerate slowly, forestry requires a long-term commitment, a faith in the future. If governments, private companies, or communities do not feel that their efforts today will be rewarded by future benefits, they have little reason to manage their forests for sustained yields. In Southeast Asia, a sense of confidence in the future tends to be lacking among those most concerned with forest resources. The Malaysian, Thai, Indonesian, and Philippine forestry agencies all face prospects of rapid, somewhat unpredictable conversion of forest lands to agricultural uses. National governments, under political and economic pressures, are driven to produce immediate results. Private companies, given relatively short-term concessions, have little incentive to curb exploitative practices that maximize present gains.

Watershed management is an area of forestry conceptually distinct from silviculture. Its goal is the manipulation of upland environments to achieve optimal and continuous water yields and soil stability. Watershed management systems prescribe how site productivities can be directed, not into commercial timbers, but into ecosystem structures most conducive to soil and water conservation. They depend even more on ecological knowledge than do silvicultural systems. However, because they lack the promise of direct economic compensation that silvicultural systems hold, they have received much less research attention. Southeast Asian nations today, notably Indonesia and the Philippines, are becoming aware of the disastrous conditions of their watersheds and of their inability to deal with them. Research and development activities are beginning "from scratch" at a time when barren hillsides and silted streams are already extensive.

Plantation forestry systems often combine silvicultural and watershed management objectives. Trees are planted to cover and stabilize denuded hillsides as well as to produce wood products. Plantations pose a question which is significant for agriculture. To what extent should they be grown as monocultures? Foresters have found that the more diverse a forest stand, the less vulnerable it is to attacks by insects, rodents, diseases, wind, and fire. With most crops, the greater economic benefits obtainable through monoculture more than justify expenditures on pest, disease, and other environmental controls which compensate for loss of natural stabilization processes. This is generally not the case in forestry, and may not be so in the agriculture of many areas in Southeast Asia. In these situations, diversity is an instrument of production.

New Cereal Varieties

The widespread cultivation of new cereal varieties, such as the high-yielding IRRI rices, simplifies environments more than do usual monocultural reductions in species number. It also reduces the genetic diversity of traditional monocultures. The threats of ecological instability associated with monocultures are compounded when the one crop possesses highly specialized, uniform genetic characteristics.

The revolutionary new grain varieties derive from narrow genetic stock. Bred for their yield characteristics under conditions of artificially high nutrient levels and excellent water control, they are replacing numerous local varieties selected through hundreds of years of experience as the most suitable in local environments and most resistant to local pests and diseases. Some pest and disease resistance has been bred into the latest rice varieties developed at IRRI and its associated institutes. Nevertheless, widespread planting of a few, highly specialized varieties is creating a hazardous situation in Southeast Asia. Experience has already shown that the new rice varieties are prone to pest and disease attack because of their growth habits, the different microclimates they create, and their higher nutrient status. It also probably results from their limited genetic resistance. Scientists at IRRI and at national agricultural institutes in Thailand, Indonesia, and the Philippines are studying this problem.

The danger is that local pests or local strains of fungus, bacteria, or virus may be able to multiply on the new varieties and, because of continuous cultivation, spread into major outbreaks. In North America, large acreages of wheat, of relatively few varieties, have been grown successfully for many years. However, the North American situation provides no model for Southeast Asia. The wheat belt is subject to frequent explosive outbreaks of pests and diseases. Such outbreaks are effectively contained by sophisticated, well-equipped, and organized extension and research services that provide constant surveillance. In Southeast Asia, these facilities are not available. Reliance will be increasingly placed on blanket prophylactic applications of pesticides, the environmental consequences of which can be overwhelming. Integrative control strategies, highly specific attacks on the crucial determinants of pest and disease cycles, offer superior alternatives but will require a great increase in knowledge of tropical ecosystem and population dynamics.

Pests

Pests, diseases, and weeds are obvious symptoms of ecological imbalance.* They are an inevitable consequence of development in almost any form, reflecting the tendencies of nature to fill voids created by simplification and specialization of an ecosystem. They are major factors in the production of almost all crops grown in Southeast Asia and are also problems in reservoirs and irrigation schemes.

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*Further discussion of pest ecology is found on p. 78.

Human diseases are also often related to development projects, especially when insects or other invertebrates transmit diseases. Schistosomiasis, a serious debilitating disease caused by organisms (flukes) which spend part of their life cycle in water-dwelling snails, has increased dramatically in Egypt since construction of the Aswan Dam. Extensive irrigation could elevate it to a disease of major importance in the region. Existing sanitation standards enhance this danger by allowing human wastes to contaminate water supplies and the disease-causing fluke to complete its life cycle. If sanitation technologies were as advanced as those for dam and irrigation systems, this and other water-borne diseases would be less of a threat to human wellbeing.

Mosquito-borne diseases are increasing in the region. Rural and urban development can create conditions ideal for mosquito breeding. Forest clearings and city trash dumps are particularly conducive breeding sites. Land settlement schemes in Western Malaysia have been abandoned because of malaria. In Bangkok and other Southeast Asian cities an essentially new mosquito-borne disease, dengue hemorrhagic fever, has thrived.

Since World War II, the response to pest and disease problems in Southeast Asia, as elsewhere in the world, has been the increasing use of chemical curatives: insecticides, fungicides, herbicides, and antibiotics. Many of these chemicals, as we now know, have toxic effects beyond the organisms at which they are aimed, and cause complex and widespread environmental problems. Such effects, documented in North America and Europe, are also present in Southeast Asia. In Indonesia, for example, the recent extensive aerial spraying against ricefield pests resulted in large kills of fish and cattle. Many Javanese farm ponds no longer support any fish life. More subtle effects have apparently resulted from spraying mosquitoes in Northern Thailand, Borneo, and other parts of the region. Insecticide deposits have been picked up by cockroaches and other insects and passed on by house lizards to cats. The cats have died and village rat populations, with their attendant disease hazards, have exploded. The effects of indiscriminate chemical use have yet to be fully appreciated.

Not only are chemicals environmental polluters, they are often inefficient tools for control. Non-regulatory in action, they rarely give more than temporary control. They are not selective, killing off natural controlling agents, such as parasites and predators, as well as the target pest or disease. Organisms develop resistance to them. In Malaysia, widespread use of dieldrin as a prophylactic against pests of oil palms only served to create worse problems. Malaria is increasingly resistant to a range of antibiotics while malarial mosquitoes do not respond to controls that were effective only several years ago.

We need an approach to pest and disease control based on a better understanding of ecological processes. Integrated strategies of pest control would utilize natural and imported control agents as well as selective and strategically-timed chemical and mechanical methods. This will provide a suitable response to the ecological complexity of the tropics, and produce economic, efficient control with far fewer hazardous or destructive side-effects.

Multiple Cropping

The loss of natural stabilizing mechanisms is one of the costs of agricultural specialization. Insecticides, fungicides, herbicides, soil fertilizers and admendments, protection skills, research, and equipment must be provided to replace natural services at the expense of other social needs. Indirect social and economic effects of their production, distribution, and use generate additional social costs.

Given the growth of ecological understanding and perspective, we may no longer need to accept these costs of environmental specialization as inevitable consequences of agricultural development. Cropping systems are being developed that offer the productive benefits of modern agriculture while increasing rather than decreasing natural interactions within a cultivated ecosystem. Theoretically, diversified systems, combining and rotating different crops in the same field, can be designed that control pests and diseases by their internal dynamics, maximize internal replenishment of soil nutrients and crganic material, reduce requirements for chemical fertilizers and admendments, and take advantage of complementarities in the growth habits of different crops to fully utilize available surface and soil space. Their vegetative structures can be managed to achieve optimal conversion of solar energy and moisture supplies. Such systems, variously described as multiple cropping, intercropping, and mixed cropping, attempt to duplicate the productive efficiency and ecological stability of the climax rainforest.

Multiple cropping, intercropping, and mixed cropping are widely practiced in Southeast Asia, but until recently little scientific attention has been devoted to their refinement or viability in a modern economy. This is changing. Scientists at IRRI, Chiengmai University, and elsewhere are experimenting with a number of multiple cropping systems. Their work displays an artistic blend of the ecological astuteness of good forestry, the environmental diversity of shifting cultivation, and the economic productivity of modern agriculture.

At present, the strengths of modern multiple cropping systems are more theoretical than practical. Economic feasibilities have yet to be demonstrated, nor have the agronomic systems been ready for such analyses. Nevertheless, there are important social, as well as ecological reasons to increase the intensity and scope of exploration. Relatively few Southeast Asian farmers will benefit from current advances in specialized agriculture. Most agricultural areas can never afford the water control systems that new cereal varieties require. Even if the proposed Mekong program is fully implemented, for example, only 11 per cent of cultivated land in Northeast Thailand will be served by irrigation facilities. In addition, specialized technologies may contain substantial economies of scale, increasing the economic size of farm operations and replacing labor-intensive with capital-intensive methods. Such tendencies strain the economic and social systems of huge rural populations. Multiple cropping alternatives should benefit all farmers, whether working in irrigated or rainfed conditions. They can depend relatively more on labor capacity and environmental knowledge than on capital resources and can help to diversify agricultural production. When developed, they might help stabilize and improve rural life, free capital resources for industrialization, and slow migrations to urban areas unable to absorb them.

Urban Development

As ecosystems, cities use resources more intensively, are more productive, and alter natural conditions more drastically than do project or upland multiple-use systems. Although dominated by human decision more than are other ecosystems, the city contains tensions between the needs for environmental stability and beneficial productivity similar to those we have discussed for less intensively developed systems. The cropped field announces its instabilities with pest and disease problems, accelerated erosion, or declining productivity. Pollution, congestion, disease, transportation and communication difficulties, decay, uncontrollable growth, and related social problems are analogous urban indicators of environmental stress. Cities are complex living systems. As for other living systems, decisions about their development must include ecological considerations.

The cities of Southeast Asia differ markedly. Their differences arise from the unique sets of cultural, economic, political, natural, and historical circumstances that have determined their patterns of development. Their sources of environmental difficulty are just as varied.*

Singapore, for example, is an island city-state located at a major crossroad of international trade. Its population is cohesive, predominantly Chinese, and entrepreneurial. The government's authority is strong and its scope of action broad. Modern sewage treatment facilities serve the entire urban population and 60 per cent of the island. Transportation systems function well. Governmental programs and immigration controls help limit population growth. Such forceful governmental actions as the development of industrial estates have effectively separated industrial from residential and commercial activities.

Future environmental problems will not result from apathy or disinterest. Rather, they are likely to spring from the vigor and success of the nation's efforts to industrialize rapidly. The conflicts of intensive industrial development and rising consumption standards with the quality of urban life are already apparent. While the government will doubtless zealously attack environmental problems created by its citizenry, there will be some reluctance to impose controls that might discourage industries it wishes to attract to its shores. Many Japanese industries are locating in Singapore partly because their environmental effects are no longer tolerated in Japan. The conflict between meteoric industrial expansion and urban quality is sharpened in Singapore by the government's absolute determination to achieve both.

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*Further discussion of urban development in Southeast Asia emphasizing ecological approaches to problem solving is found on pp. 57-62.

Bangkok is a sprawling city on the Central Plain of Thailand. As the national center of government, commerce, industry, and culture, it has a population more than thirty times that of the second largest city. Thais have traditionally adopted a laissez faire attitude toward the development of Bangkok that has enhanced the graceful charm of the "Venice of Southeast Asia," with its beautiful temples and delightful canals. In the present, such an attitude prevents the adequate management of urban growth. The population of metropolitan Bangkok has tripled since 1950; the number of automobiles is thought to have doubled in the last five years; most canals have been paved to provide roads and the remainder converted to open sewers. Public transport is uncoordinated; the movement of people and goods within the city has become a major problem; and sewage disposal is the responsibility of the individual householder.

There are no effective land use controls. The city is now a confusing, unorganized agglomeration of factories, residences, shops, offices, streets, and unused land. Bangkok, rather than altering its structure to suit the needs of urban growth and development, has expanded by amoeboid fission across the flat landscape. It is now feeling the stresses of such incoherent growth. The strangulation of traffic, air and water pollution, shortages of decent low-cost housing, and the phenomenal costs of improving urban services are immediate problems. The conflicts between traditional Thai freedoms and the functional requirements of an urban-industrial area will shape Bangkok's future.

Greater Manila is a city of extremes. Wealth and poverty, modern and peasant, industrial and agricultural, mingle, but do not cohere into an effective urban society. Manilans, wanting organization and planning, have been unable to evolve responsible authority for the city congruent with traditions of the villages from which they came. Governments do not provide such authority. As a result, most decisions about city development are made by default.

Manila is dominated by large slums housing the majority of the citizens. Streams and canals provide the water supply and sewage disposal for these areas. Health hazards are substantial. The centralized sewage disposal system discharges its untreated wastes directly into Manila Bay. Industrial wastes have the same terminus. Most factories, whether producing modern goods or processing coconut, timber, starch, or sugar, are located along waterways into which they discharge their effluents, seriously polluting the Tinajero and Pasig Rivers. Many effluents are toxic and harmful to the health of slum communities that must drink water downstream from industrial discharge points.

Air pollution is less of a problem as yet. Nevertheless, about 3,000 tons of atmospheric pollutants are discharged by motor vehicles in Manila each day. Industrial discharges also contribute to the city's perpetual haze, but some companies are beginning to curtail them voluntarily. This may signify emergence of a sense of private responsibility that can help to knit the people and environment of Manila into a viable community.

Jakarta, our last example of a Southeast Asian urban ecosystem, is relatively simple to describe and difficult to understand. The city seems a concentrate of rural Java. It displays the economic, social, and physical diffuseness of the countryside, and the same environmental problems: crowding, poor communications and transportation, disease, and low standards of living, productivity, and public services. With a population of almost five million people, varying significantly with the seasons, the city's decentralization of function may be the basis for its survival. As development proceeds, the specialization and concentration of urban functions must inevitably occur. Interdependence will increase within the city. Needs previously met by traditional responses and values will become the responsibility of the urban system. Natural stabilization processes will be lost and will require replacement by appropriate technical and institutional means. The sequence has begun. The future promises far more serious problems of environmental management than now exist.

Marine Resources

To go from the city to the sea is not a big step in Southeast Asia. Most cities are coastal or are a short distance inland on a major river. Their waste flows into bays, estuaries, and the open sea, creating serious problems for local fishermen and for the cities themselves if their discharges overload natural flushing capacities. There are also broader implications.

Much of the vast ocean area of the world is a biological desert. The living wealth of the sea is concentrated in limited localities on the continental shelves. There, plankton, seaweed, prawns, crabs, and fish of all kinds thrive under ideal nutrient and physical conditions. The highly productive estuaries and coastal swamps supply abundant nutrients, provide protective nurseries for the young, and maintain environments essential for the survival of organisms at various stages in their lives.

The seas of Southeast Asia are among the world's richest marine ecosystems. Little is known about their complex ecology or about current rates of catch, but they are obviously underexploited at present. This vast wealth is threatened, not primarily by fishermen, but by human activities on the adjacent rivers, estuaries, and swamps and on the continental shelf. Rivers are dammed and their flows of nutrients halted. Estuaries are used as sinks for urban and industrial wastes. Coastal swamps are drained for agricultural and urban development. Oil drilling and tin dredging on the continental shelf create additional hazards for marine life. The effects of such activities extend throughout the fisheries of Southeast Asia.*

Three of the world's major urban-industrial complexes can be expected to develop at biologically vital locations in the region. The first is already taking form and will eventually comprise southern Johore, Singapore, and the Singapore Strait islands of Indonesia. The second will cover a large swath of the Thai coast along the Gulf of Thailand. The third will ring Manila Bay. All are likely to have profound effects on marine life. This does not mean that their development is undesirable, but that it can be destructive unless planned and executed with sufficient consideration for ecological factors and for social costs and benefits not currently weighed in development decisions.

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*Innovative programs in marine ecology are discussed on p. 79.

III. THE CONTEXT OF CHOICE IN RESOURCE DEVELOPMENT

Resource development creates environmental problems when choices of farmers, fishermen, loggers, industrialists, urbanites, and governments compete with the dynamics and capacities of ecological processes. Choices about resource use, whether generated by the habits of traditional farmers or the sophisticated calculations of government planners, are summary responses to a complex web of pressures. They reduce to simple statements complex perceptions of need and of nature's potentialities, of institutional constraints, and of available techniques. Environmental problems arise when the effects of choices begin to diminish nature's capacities to satisfy human needs. Their amelioration depends as much on comprehension of the forces affecting human behavior as it does on understanding their natural qualities.

Problems are social as well as ecological. Residents of Southeast Asia manipulate their environments in response to the constraints, desires, and values of their societies. While it may seem dangerous to generalize about constraints and value patterns in a region so diverse, some themes can be suggested as examples of forces affecting resource use and as starting points for future analyses.

Economic Development

The urge for economic progress is common to all the nations of Southeast Asia. Governments strive to raise productivity, satisfy demands for higher standards of living, meet the needs of expanding populations, and improve their abilities to withstand external political pressures. Lack of capital goods and the foreign exchange to purchase them abroad are major bottlenecks in development efforts. The scarcity of capital creates strong incentives to exploit and export natural resource products: agricultural and aquatic commodities, oil, minerals, and timber. This will continue far into the future.

The development of natural resources for economic benefit is desirable, unless accomplished at rates and by means detrimental in the long run. Whether resource development programs prove to be beneficial or destructive depends largely on how far scientific knowledge is applied in their formulation and on the ability of government agencies to control their implementation. In Southeast Asia today the impulse for rapid economic development is far stronger than the social incentives for scientific investigation or for the advancement of capabilities in government resource management.

Government

Control of resource use is primarily a government responsibility. Resource management agencies in Southeast Asia typically lack sufficient training, techniques, tools, and funds to cope adequately with the situations they are supposed to regulate. More important, however, is the weakness of incentives for effective performance. Salaries are generally small compared to those in the private sector and advancement does not always go to the most competent. Opportunities for recognition by fellow professionals are severely restricted by poor communications within professions and fragmentation of function among many competing agencies. Governments tend to deny political support to resource management agencies, fearing that controls on resource use will blunt economic development and incur shattering political reactions. Legal prescriptions are often incompatible with social patterns and technical needs. These conditions weaken agency morale, authority, and effectiveness.

Tradition and Perceptions of Nature

Traditional patterns of behavior, whether enforced by customary sanctions and rewards or supported by shared perceptions of nature and scarcity, often determine how men manipulate their environments. Legal and judicial procedures, market processes and policies, and voluntary associations also influence decisions about use of natural resources.

Historically, traditional institutions often encouraged sound environmental management choices. However, their rigidities now prevent adjustments to the new strains imposed on natural resources by burgeoning populations and modern technologies. Land and water laws, rooted firmly in tradition, are often incompatible with sound resource management in a developing and industrializing country, and are unable to resolve conflicts among competitive uses.*

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* For a discussion of environmental law in Southeast Asia, see pp. 64-68.

Philosophical views about the relationship between men and nature are important in resource management. Western tradition separates man from nature, assigning him the authority to manipulate his environment and the responsibility to preserve it. This tradition has fostered science and technology with their tremendous capacities for environmental disruption. At the same time, it has encouraged awareness of the destructive effects of human activities and has stimulated the interest and ability to control such effects. Present conflicts between the advocates of "environmental quality" and of "technological progress" are contemporary manifestations of an age-old dilemma.

Asian philosophies tend to avoid this dilemma by viewing men as participants in, rather than overseers of, natural environments. They value the attainment of harmony within nature, not the compulsion to objectivize and dominate it. They esteem knowledge through immediate experience rather than by analysis and abstraction.

This view provides a comforting palliative for the current woes of the West. The philosophy of harmony and integrity resembles what Western environmentalists are trying to formulate in response to the contradictions within their own tradition. Yet, however desirable it may now seem from the Western point of view, it does not support the growth of a scientific tradition and institutions in Asia which can help accommodate to the incursions of modern technology, the pressures of population growth, and rising consumer expectations.

Population

Population growth is a major factor affecting environmental resources in Southeast Asia. The population of Thailand is expanding at a rate of 3.2 per cent per year, that of the Philippines at 3.1 per cent per year, Indonesia at 3.1 per cent per year, and Malaysia at 2.8 per cent per year. This reduces the per capita availability of natural resources. When combined with desires for much higher standards of living, increasingly efficient extractive technologies, and the weakness of resource management institutions, the growth of population poses an ominous threat to the future of Southeast Asia.

The distributions of populations are as significant for resource use as are their absolute sizes and rates of growth. Resources are the properties of specific locations. The populations they support in these locations determine the intensities of demands placed upon them. Over- or under-populated imply judgments about the desirability of specific relationships between resource capabilities and human pressures on them, between rates of exploitation and rates of regeneration. To understand Indonesia's resource situation, for example, it is probably more important to know that two-thirds of the country's population is located on the island of Java than that the total population is almost 120 million and growing at 3.1 per cent per year.

Governments recognize the significance of population distributions for resource use. Some attempt to influence distribution patterns through various policies and programs. Others avoid direct confrontation with the forces that affect locational choices of individuals, industries, and communities. All make decisions, whether active or passive, about the patterns of distribution they are willing to accept.

Urbanization

Perhaps the most powerful force causing changes in population patterns is urbanization, the shift of populations toward cities. Cities are growing at much more rapid rates than national populations. Metropolitan Bangkok, now over 3 million people, is increasing by 5.5 per cent per year. Greater Manila, with 4 million people, is expected to reach 8 million in the next decade. The population of Jakarta has almost doubled since 1960 and will probably double again by 1980. Such expansion strains the abilities of governments to control the evolution and decay of urban areas and to compensate for the growing disparities between environmental capabilities and human needs. It also influences choices about resource use throughout the urban hinterland.

Nationhood

The spatial distributions of population also cause Southeast Asian countries' difficulties in achieving national unity. The geographical scatter of Indonesia and the Philippines imposes burdens on their scarce administrative and political resources, strains thin lines of communication, and frustrates efforts to integrate dispersed communities into one nation. Cultural, economic, and ideological divisions, often deepened by physical separation, also threaten the nationhood of all countries in the region save Singapore.

It is difficult enough for governments to maintain public support by satisfying divergent interests. When that function is combined with needs to prove the desirability of nationhood, stimulate rapid transformations of traditional economic and social patterns, and reduce national vulnerability to the influences of foreign power, governments are faced with apparently insuperable demands. Understandably, national unification is assigned dominant priority in government policies.

The results of such policies strongly affect resource use. Extreme examples are provided by the civil wars in Indochina, which obviously determine most resource decisions at personal or public levels. Differential treatments for communal and economic groups are other examples of policies that become manifest in patterns of resource use. Selective assistance for development of specific activities in the economy, usually justified in economic terms, often derives primarily from political considerations. Movements for self-sufficiency in rice production, dam and highway projects, decentralization of economic opportunities, promotion of heavy industry, and land development programs are often responses to political rather than environmental-economic judgments.

International Position

The countries of Southeast Asia are vulnerable to pressures from outside the region. Whether applied politically, economically, or militarily, these pressures elicit policies in response to them rather than in response to domestic needs and initiatives. National policies and programs are susceptible to the controls accompanying foreign aid and investment, the vagaries of international commodity prices, monetary conditions and power relations, the stockpile and trade policies of industrialized nations, and rapid technological change. Future conditions are relatively unpredictable and possibilities limited, encouraging quick exploitation of accessible opportunities and resources. Choices in resource use are thus guided in directions more beneficial to foreign than to long-term domestic interests.

IV. ORGANIZATION AND INNOVATION FOR PROGRESSIVE RESOURCE DEVELOPMENT

Environments are unique to their location. Problems arising in them must be solved by local knowledge and institutions. Indeed, many result from the uncritical import of technologies, ideas, and forms of organization.

Institutional patterns and innovative activities which can assure the optimal development of resources are weak in Southeast Asia. Many feel that concerns for environmental issues compete with efforts to achieve economic and social progress and are luxuries which developing countries can ill afford. They assume that environmental deterioration must be risked for developmental aims. The effects of deterioration, however, generally compete more with these aims than do searches for means of reducing them. Learning to handle environmental stresses increases productive capabilities and can ease limitations which now constrain developmental activities.

Emerging institutional patterns and innovative activities in Southeast Asia today signal a growing appreciation that environmental and developmental matters are not separable in the drive for higher levels of welfare. In the following sections, we review some trends in regional development, multiple use management of resources, scientific and technological innovation, administrative and legal means for resolving conflicts in resource use, environmental policy and planning, and public education, which promise an improved and expanded range of developmental opportunity through ecological insight. We argue that they are important and deserve much more support than they now receive.

Regional Development Perspectives

Regions vary according to the internal relationships people select to define them. When interdependence of water relations is of concern, the region may be a river basin. When movements of people, materials, and information are important, it may be the extent of a city's influence on the hinterland. Common problems, culture, resources, and politics are other criteria for definition. The essence of a region resides in the unique human and natural relationships that create its identity.

All regions, however defined, represent human belief that they can be treated as units. When assigned purposes related to resource development, they become operational ecosystems. Their development should be a process of integrating human actions and ecosystem dynamics to yield both economic productivity and environmental stability.

There are many regional approaches to development in Southeast Asia. The following sample the diversity of conditions, strategies, and opportunities that they display.

The Frontier Region

Eastern Kalimantan is rich in unused resources and sparsely settled, with diffused flows of commodities, services, information, and administrative control. Its natural wealth is just beginning to feel the bite of exploitation. Governmental receptiveness to foreign investment and large inflows of capital have fostered a dynamic situation that holds great promise for Indonesian development.

It also threatens the region's future because the rapid release of natural wealth cannot presently be regulated and is accompanied by waste and deterioration of resource potentials. Present decisions are determining patterns and problems of future Kalimantan development. The location of roads, processing plants, shipment points, markets, and cleared areas by private criteria, the population shifts and social effects caused by extensive logging, and the patterns of land tenure wrought by concession of huge territories to corporations, will constrain the shape, content, and distribution of regional agricultural and industrial possibilities.

Sound resource management is essential for the optimal development of eastern Kalimantan. This does not mean that exploitation should be curtailed until management capabilities become adequate. The benefits of private investment, new technologies and skills, resource information, additional income and jobs are too important for Indonesia. It does suggest that the vitality, revenue, and lessons of the current events be captured effectively in the form of knowledge, management techniques and skills, governmental capacities, administrable regulations, integrative mechanisms, and infrastructure for regional development.

Trends are encouraging. The Governor of Kalimantan Timur is following an astute strategy of regional development based on the scarcity of public managerial capacity. He guides private decisions toward public goals by judicious persuasion, incentives, and catalytic actions, investing government resources to link dispersed private infrastructural networks. At the same time, he supports development of forestry education and research in the region, training of provincial officials in planning, economics, and administration at national institutions, and collaboration between his staff and national centers of competence.

The Malaysian Federal Land Development Authority's approach to frontier development contrasts sharply with that in eastern Kalimantan. The FLDA selects a strategically located and potentially agricultural stretch of forestland, determines its crop possibilities and population capacity, clears it, plans and implements the layout of villages, family plots, and individual houses, chooses settlers and facilitates their movement, provides a full set of public services, and links the area to the national network of roads, markets, and urban centers. The approach is comprehensive, controlled, and generally successful. It is a response to problems of income and population distribution rather than to the capital and administrative scarcities that dominate Kalimantan.

Unanticipated ecological effects of extensive forest clearance and cultivation pose serious risks to the FLDA's developmental objectives. Opened conditions have proved favorable for the spread of malaria, forcing the abandonment of several projects. They have also generated agricultural pest outbreaks of unexpected severity.

The River Basin

A frontier region gains definition through efforts to impose some productive shape on a set of previously undifferentiated possibilities. A river basin, however, possesses its own hydrologic patterns of interdependence and focus. When water is a crucial determinant of potential welfare, these relationships become important guides to development strategy.

The Barito Basin of south-central Kalimantan is a frontier region in which control and management of water resources are keys to development. Its extensive lowlands have rich agricultural potential that will remain underutilized until irrigation and drainage facilities make the area attractive to migrants able to exploit it. The predominant role of water in the basin, the scarcity of private initiatives, and the need for large infrastructural investments have encouraged an integrated planning approach to regional development. If plans are fulfilled, the basin should be able to support a population ten times its present one at reasonable levels of welfare. But technicians and capital are lacking for plan implementation. Perhaps more important, those migrants who do come find marketing opportunities and production incentives extremely weak. Development of the basin requires that its economic links to other parts of Indonesia be strengthened.

The Barito case demonstrates that underutilization of resources, as well as excessive use, is an ecological problem in development. The untapped potential of the basin relates in stark contrast to the crowded lands of Java only several hundred miles away, and comprises one aspect of environmental stresses on Java. The basin must be developed, not only with sensitivity to its capacities and relationships among forests, uplands, lowlands, streams, settlements, and the estuary, but also with due consideration to barriers which discourage migration from Java and weaken incentives for developmental actions.

The Mekong Basin is much larger and more complex than the Barito system. Flowing from eastern Tibet to the South China Sea, the Mekong river traverses about 2600 miles in six nations. Basin population in Thailand, Laos, Viet Nam, and Cambodia alone exceeds thirty million persons (sixty million by the year 2000), most living at low subsistence levels. The river's great resources, virtually unexploited, offer tremendous promise for improving the welfare of those residing along its reaches.

Integrated development of the Mekong must begin with proof that the potential benefits of international cooperation justify the required changes in national sovereignty. The Committee for Coordination of Investigations of the Lower Mekong Basin, presently composed of representatives from four nations, and its Secretariat of planners, were established for this purpose. After fifteen years of slow but perceptible progress, they have achieved international agreement on a plan for technical coordination, as well as a collective expertise that is likely to stimulate other forms of harmonization in the future. The mere existence of a plan with its comprehensive information has already guided different basin nations toward complementary decisions. Eventually, more formal patterns of coordination and cooperative authority should emerge.

Potentially adverse environmental consequences of Mekong development were mentioned earlier. They must be adequately considered by planners if the expected investment of $12 billion is to have its intended effect on regional welfare. Of greater institutional significance, however, are two other aspects of ecological concern. First, environmental costs of development will not be distributed equally. Changes in fish population, land inundation and resettlement, and soil salinization, for example, will bear on specific localities and nations, not on the whole region. Even informed management may only transfer the incidence of environmental strain rather than eliminate it. Maintenance of minimum dry-season flows to prevent salt-water intrusion in the delta, for example, may be at the expense of upstream irrigation projects. The distribution of developmental benefits is a source of contention among basin nations. The distribution of environmental costs is likely to become so as well.

Second, detrimental effects of upstream activities on water quality, quantity, and timing will become increasingly apparent as uses of the river intensify and grow more interdependent and valuable. Felt most by nations downstream from those in which they are produced, they may add to institutional strains that concentrate in the Mekong Committee. The Committee and Secretariat will need the capacity to understand and integrate ecological considerations within their policy-making, planning and management efforts, and the scientific expertise to resolve disputes.

The prospects and problems of Mekong development will evolve over a century. Those in the Lake Lanao-Agus River region of northwestern Mindanao are immediate. Construction of a hydroelectric dam at the mouth of the lake is imminent, with many negative as well as positive implications for regional development. Alternatives to the single-purpose hydroelectric plan, prepared by one specialized agency, have not been formulated. The Agus River flows northward into Iligan Bay from the 134 square mile Lake Lanao. With a short span and steep gradient, it has perhaps the greatest hydroelectric potential of any stream in the Philippines. When fully harnessed, it is expected to have a generation capacity of 850,000 kilowatts. Electricity will stimulate industrialization in Iligan City near the mouth of the river and in other parts of resource-rich Mindanao. The proposed dam will lower the lake surface by as much as 26 feet during the dry season. Experts say this will have major destructive effects on the fishery and also jeopardize lakeshore agriculture and the livelihood of local communities.

The present plan must be judged unsatisfactory until more comprehensive alternatives have been proposed and evaluated. The Lanao-Agus region, from hinterland to the sea, is an ecological and economic entity and should be developed with attention to its whole range of forest-fisheries-agriculture-industry-settlement relationships. Many organizations in Mindanao share this view and have the competence to implement it, but political, cultural, and administrative fragmentation have prevented the necessary coordination. The growing convergence of interests and skills among congressmen and local leaders, the Bureau of Forestry, the National Power Commission, logging firms, and the dynamic regionally-oriented Mindanao State University in the lakeside city of Marawi, provide fruitful possibilities for cooperative effort and pooling of information. The Institute of Planning at MSU may be the suitable catalyst for more effective organizational relationships. The relaxation of institutional constraints, and the resulting increase in available information and ideas, should broaden the range of productive alternatives for basin development.

The Urban Region

The North of Thailand, a maze of mountains and valleys, shares river basin characteristics of the Lanao region. Land and the technical and institutional means for increasing welfare derivable from it, are the critical scarcities imposed by population pressures. Flows of people, goods and services, ideas, and information are becoming the organic bonds of the region. The basis for social integration lies in the radial patterns of marketing, highway and communications development, governmental administration, and migration which pivot on the city of Chiengmai.

Programs, planning, and policies emanate from Bangkok and are dominated by a perspective of the North as a headwater hinterland. Programs are rarely coordinated. Authority and capacities for similar functions are generally dispersed among many agencies. Development planning has been preoccupied with national aggregates. Planners have tended to view regional development as a counterpoise to metropolitan growth rather than as a promising and necessary element of strategy.

These conditions may change. The National Economic Development Board, in its Third Five-Year Plan (1972-1976), pays thoughtful recognition to past shortcomings in regional planning and outlines some promising new directions. It has opened an office in the North. Information about rural problems is increasing and, along with other experience, is focussing attention on policy aspects of regional issues.

Development in Northern Thailand has relied on strengthening urban centers. In the metropolitan regions of Bangkok and Manila, however, trends toward centralization have reversed. Intensification has proceeded at their cores to the point where the benefits of concentration are succumbing to the costs of friction. Flows of people, messages, goods, services, water, and waste discharges are increasingly unreliable. Institutions have have not evolved rapidly enough to prevent social disruptions, provide adequate housing, or control undesirable uses of resources. Bangkok and Manila display growing vulnerability to traffic freezes, crime and violence, contaminated water and air, and despoiled or poorly utilized land.

The result is the gradual and selective dispersion of activities, people, and wastes. In Bangkok, universities, industries, and residents are moving up to fifty miles from the metropolitan center while the periphery continues to drift outward. Around Manila, industrial and suburban developments are encircling Manila Bay and Laguna de Bay. In both cases, selective flows of migrants to the city and from the congested center to previously rural areas are having significant effects on the socio-economic composition, functions, and relationships of the region.

The effects of dispersion are ambiguous. Dispersion shifts highly productive technologies and new sources of employment and income to rural areas, and weakens traditional barriers to development. The land speculation that accompanies it, however, causes insecurity of farm tenure, reduces incentives for long-term farm investment, undermines social stability, and increases rural migration to the city. Additional migrants exacerbate the city's problems of sewage and garbage disposal, water supply, housing, and communications. While dispersion lessens industrial pollution in the city and relieves urban strains of truck, boat, and rail traffic, it also increases flows of commuter vehicles from suburb to center. In the suburbs, upper- and middle-income families find the open space and residential qualities they desire, but take with them the political strength and private resources which might otherwise apply to regulate land use, provide parks and recreation areas, and improve the quality of urban life.

Dispersion changes the composition of stimuli and strains resulting from urban growth. It does not eliminate the costs, nor does it necessarily increase the benefits, of environmental intensification. It merely transforms them, shifts their locations, and alters the qualities of interdependence among ecosystems in a metropolitan mosaic. Comprehensive evaluation should expose a range of alternatives for metropolitan development that improve access to a more optimal distribution of resources, capabilities, people, and opportunities.

Dispersion in Bangkok and Manila has been motivated primarily by desires to escape or relieve congestion in the city rather than by choice based on development strategy. Possibly the costs of congestion are felt while those of dispersion are not, or the interdependence of conditions at the metropolitan periphery and center is not sufficiently appreciated. Recent formation of a Metropolitan Bangkok Municipality, the Laguna de Bay Development Authority, and a coordinating council for municipalities in Metropolitan Manila is encouraging. So is the growing interest of national agencies and scholars in metropolitan issues.

Multiple Use of an Ecosystem

Integrative approaches to regions should stimulate choices and actions that productively relate diverse but interdependent ecosystems without loss of environmental stability. However, whether they foster optimal resource use depends on how effectively component ecosystems are managed. Interactions among badly used sites are unlikely to be desirable. The problems of managing individual ecosystems are not necessarily solved by regional approaches.

Integrated approaches to ecosystem management have many titles, including multi-purpose planning, multiple-use management, and city planning. They often represent hopes more than practices. Ecological relationships are rarely understood with sufficient perception to allow estimates of environmental "trade offs." Little is known, for example, about the extent to which cutting timber alters upland water storage, yields, quality, and rates of flow. Management techniques vary widely in quality and development. Witness the disparity between sophisticated dam construction methods and the comparatively primitive methods of reservoir fisheries management. Environmental value relationships are often undefinable or are difficult to use in decision-making processes. How hard it is to compare the value of industrial development with the social cost of subsequent urban pollution. Finally, dispersion of responsibility for a single environment among specialized agencies is ubiquitous, reflecting, in part, inadequate appreciation of the character of ecosystems.

Environmental planners and managers must make decisions using available information. As a result, their decisions do not exploit the potential benefits that an ecosystem could yield with more fully informed management. Attention is devoted to activities requiring proven technologies rather than those of less assured result. Measurable economic values are emphasized at the expense of less tangible costs and gains. The problems of ecological stability tend to be ignored, and opportunities for coordination of different activities are frequently missed. Many of these suboptimal biases in decisions can be overcome by the extension of knowledge about environmental management.

Reservoirs

Reservoirs are classic projects. Created to increase human welfare, they do so by completely changing local environments. When planned and managed with insufficient information and method, unanticipated consequences can reduce or even outweigh their intended benefits. Reservoirs will become a dominant feature of the Southeast Asian landscape, especially in the Mekong Basin. Attention to their ecological processes and to the development of adequate planning and management techniques is therefore important.

The Nam Phong project is a useful point of departure for development of multi-purpose reservoir management systems. Several analyses of it have been completed and should supply bases for future work. The Mekong Secretariat has prepared excellent fisheries research proposals that cover problems of river, lake, reservoir, and estuarine management. South Vietnam and Cambodia have expressed concern about possible effects of basin development on their valuable fisheries. Execution of the Secretariat's proposals should provide answers to some significant economic, scientific, and technical questions. Perhaps their most significant product, however, would be a rationale for coordination between specialized management agencies and among agencies of the basin nations.

Planning agencies, alerted by situations such as the Nam Phong reservoir and the Agus River dam, are asking questions they hope will reveal ecological weaknesses in proposals presented to them. They tend to assign such questions low priority, partly because of the lack of practical methods that will permit inclusion of ecological factors in systems of project analysis and planning. Rapid development of such methods should be encouraged.

Academic institutions offer potential sources of new analytical methods for planners. In Southeast Asia, the Asian Institute of Technology and University of the Philippines are actively developing ecologically-sensitive methods of project evaluation and management. Economists and environmental engineers at AIT, and professors of public administration, economics, and planning in the UP system, are working together in promising efforts. The Institute of Planning at Bandung Institute of Technology, the Asian Institute of Management in Manila, the Faculty of Public Administration at the National Institute of Development Administration and the Faculty of Economics at Kasetsart University in Bangkok, are additional examples of planning-oriented schools that are increasing the ecological content of their teaching programs.

Uplands

Uplands ecosystems in Southeast Asia pose different management problems than do projects because they lack a discrete focus around which authority for decisions can be integrated. Agricultural, forestry, public works, fisheries, and public health agencies in upland areas interact with scattered commercial, subsistence, and shifting cultivators, loggers, and local communities. However, theirs are distinctly separate missions that extend through, rather than converge within, specific environmental points.

Upland research tends, for economic reasons, to elicit ecological perspectives and approaches. Its problems cannot be solved by the costly technical methods used in the more productive lowlands. Greater reliance must be placed on understanding natural processes of environmental control. This ecological tendency, if exploited by suitable program and organizational designs, can help to produce coordinative models with operational value.

Uplands research trends in Southeast Asia are encouraging. IRRI is gradually increasing its activities. Research stations are being developed in the uplands of the Mekong nations. Although such programs have specific aims in crop, timber, or livestock production, they share the need for ecological understanding that can lessen reliance on compensatory techniques. They seem likely to evolve integrative approaches to resource management in the process of fulfilling their specialized missions. Mutual interests in upland environments and relationships between their objectives may also stimulate interaction among them.

Professional education is another potential source of interorganizational coordination.* It can sensitize students to the values of interdisciplinary work and supply a rationale for integrated approaches to resource problems. For example, the vigorous growth of an ecology program at the University of Malaya, designed to provide comprehensive training that satisfies the needs of many different resource management agencies, is highly desirable.

Integrated upland management requires agencies that possess the flexibility to allow specialist collaboration across organizational lines and the strength to mobilize scarce specialist resources for the solution of specific problems. In Southeast Asia, the problem is to find appropriate balances between flexibility and strength, given the available pool of resource managers. Malaysia and Indonesia, for example, have relatively decentralized patterns of resource administration. Specialist coordination and authority at the state/provincial level are substantial, but collective competence at that level, and flows of expertise from the center, are weak. Strengthening state/provincial competences and increasing flows from the center are two means to improve field operations. The Philippines and Thailand, on the other hand, have tended to centralize authority and expertise, suffering effects of concentration and poor inter-agency coordination. The gradual regionalization of resource management programs in both countries should improve opportunities for integrative development activities.

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* Professional coordination and communication are more fully discussed on pp. 70-72.

Regional approaches to upland management have obvious advantages as patterns of organization. They create potential nodes of coordination closer to the location of environmental problems than are national centers. They encourage concentrations of specialists that, although weaker than those attainable at national levels, are more viable and economic than those possible at local levels. They can improve access to authority that had previously been centralized, yet reduce the intensity of pressures to which local authorities are subject.

Cities

Urban management comprises those institutional patterns that direct public resources toward advancement of urban welfare and compensation for strains that emerge in the evolution of a city. It differs from other forms of multiple use management in that urban institutions evolve within the system, rather than penetrate it from an external source, and are characteristic of individual urban areas.

Singapore is developing a strong tradition of urban management based on national unity, an effective bureaucracy, and the exigencies of an island city-state. By asserting the ultimate importance of urban welfare in its broadest sense it is seeking a balance between rapid industrialization and the enhancement of environmental quality, between economic growth and distributive justice. Its government has vigorously attracted new industrial and commercial activity by controlling wage levels and providing a good climate for foreign investment. Public housing, urban renewal, and welfare programs continue to improve living conditions for the populace and guide patterns of urban development. Aggressive establishment of industrial estates has stimulated economic progress while containing its environmental side effects. Pollution control units regulate solid waste disposal and discharges to air and water. Their recent merger into a single agency under the Prime Minister suggests the rising priority they are assigned.

Three potentially productive aspects of urban management have yet to receive the attention they deserve. First, technical measures needed for management of a compact urban-industrial system in the tropics are scarce. Singapore, despite its comparative advantage in urban management experience and engineering skills, has not encouraged their innovation. Innovative techniques for waste utilization, disposal, and control, and urban water and transport systems will be essential for Singapore's future, as for other tropical cities. Second, indigenous links between such sources of technical information as universities and research institutes and potential users in industry and government are weak. Singapore depends on foreign consultants in environmental management. This is costly in foreign exchange, lost opportunities for experience, and application of unsuitable technologies. Finally, while implementation is excellent, feedback on effects is weak. Many organizations support urban research, but little coordination has emerged among them.

Bangkok has not felt Singapore's pressure for intensified urban management because it could disperse population and industry. There is also a lesser national commitment to industrialization, and a greater reliance on private rather than communal decisions. Urban management has tried to preserve the traditional social structure under the pressures of urbanization and economic development. Management decisions derive from compromise accommodations of bureaucratic interests to maintain consensus within the government structure. As a result, problems have tended to be handled ad hoc.

Impending acceptance of a town planning law and metropolitan plan may change this situation. The law would assert public authority over a broadened range of private decisions, impose restrictions on currently unregulated uses of urban land, and provide a general guide for the location of urban activities. A clearer perspective of relationships between social strains and urban physical conditions, a greater appreciation for the city as an interdependent system, and an increasing awareness of the contributions expertise can make to urban programs seem to be emerging. Strengthening capacities of the Department of Town and Country Planning of the Ministry of Interior for urban research, design, and regulation would be extremely valuable.

University programs in urban affairs are growing. Faculties and institutes of Chulalongkorn University, for example, have embarked on ambitious studies of urban problems and planning models. They are now considering the formation of an Institute of Urban Studies. The

Faculty of Social Administration at Thammasat University is executing a series of well-conceived studies of squatter settlements and housing conditions in Bangkok. The Asian Institute of Technology has a good training and research program in environmental engineering. Given the increasing use of academics on governmental urban committees and the recruitment of most graduates into government service, developments at the universities should have a growing impact on urban policy and program formulation.

In Manila, the strains of urban life appear to far exceed government capacities to manage them. In contrast to Bangkok and Singapore, flows of information and popular demands are extremely large and varied. Public awareness of urban problems is relatively great. Research is substantial and its results receive fairly wide coverage. The government typically copes with urban management by political accommodation rather than by programmed administrative response. The complexities of political requirements and tangible conditions now appear to surpass governmental capacities for accommodation. As a result, there are strong pressures for institutional change.

The unresolved search for Philippine national identity and purpose finds its physical analogue in Manila's patchwork urban map with many competitive points of focus. Conflicts over the relative values of economic development and cultural heritage, the prevalence of corruption, and the great discrepancies between egalitarian ideals and real distributions of welfare significantly affect the management of education and public transport systems. Disputes about the appropriate division of responsibility between public and private sectors are mirrored in the fragmented attempts at barrio development, provision of low-cost housing, and maintenance of environmental quality. The resources are available for solution of many urban problems, but present institutions are not able to apply them effectively.

Among the promising signs of institutional change are the growth of professionalism in urban management, efforts by some government agencies to involve non-governmental organizations in attacks on priority problems, and increasing evidence of active social concern by businessmen. Creation of the problem-oriented and multidisciplinary Philippine Social Science Council is a step forward. The National Science Development Board, a government agency, is allocating funds to encourage the innovation of industrial technologies to make more productive use of Philippine resources, reduce waste burdens in the urban environment, and provide employment, income, and new exports. Many major Philippine corporations have committed 1 per cent of their income to a foundation, Philippine Businessmen for Social Progress, devoted to the solution of urgent social problems.

If Bangkok and Manila are beset with "second generation" problems of urbanization, Jakarta still faces fundamental "first generation" issues. Despite its huge population, the processes of concentration, differentiation, and specialization of urban functions have just begun. The city must still develop the basic urban infrastructure to accommodate and encourage rapid industrialization and growth. Physical planning of transportation systems, markets, communications, and power networks is important. Retention of balance depends more upon increasing the system's economic viability than on enhancing environmental or institutional diversity. Urban planning and environmental engineering should be priority objectives. So, too, should be the critical scanning and application of new technologies and ideas that, by introduction at this stage of development, will prevent the problems that now confront Bangkok and Manila. The present administration of Jakarta is purposeful, progressive, strong, and able to use innovative ideas and new capacities well.

Population, Science, and Resource Policies

Clearly, population size and distribution, technological alternatives, and institutional aspects of resource development are critical determinants of ecosystem capacities to improve human welfare. They are all affected by national policies, directly and indirectly, and are amenable to manipulation by policy instruments. The design and strength of family planning programs, the location and kind of infrastructural developments, the priorities in allocations for scientific and technological development, the regulation and administration of resource use, and the character of agricultural programs are all policy choices that constrain specific ecosystems.

The tendency is to formulate such policies in national aggregates and models. "What effects does this policy, or set of policies, have on specific local conditions?" is asked infrequently. Thus, population size is generally treated as a passive denominator of gross national product (GNP). The key fact that population pressures bear unequally on different ecosystems is lost in the national aggregates and averages used to determine policy. Policies favor those technologies that promise relatively immediate increases in national economic aggregates. Development of domestic innovation to satisfy the requirements of less productive systems, which will continue to contain most residents of Southeast Asia for many decades, draws lower priorities although possibly contributing more to total national welfare and equity in the long run. Resource development policies show a similar propensity for national economic aggregates, oriented more toward production and export than toward development of institutional capabilities essential for environmental management, welfare, and equity.

These shortcomings are in the perspectives of policy needs rather than in the policies themselves. Discussion of broadly-defined "population policy" has evolved rapidly and ideas produced by it are being implemented throughout Southeast Asia. National agencies are increasingly allocating funds for scientific and technological research within a broad framework of environmental-developmental priorities. The Philippine National Science Development Board and Singapore's Ministry of Science and Technology are noteworthy in their efforts to use "science policy" as an instrument for national progress. The evolution of resource policies is less encouraging, perhaps because of the tremendous barriers to their change. But relationships between population, science, and resource policies are not considered, and their capacities to reduce environmental stresses and increase levels of welfare are thereby generally lost. Except for Malaysia, integrative approaches to environmental policy issues have not been attempted.

Environmental Law

Supportive institutions, including government policies, are important for the ecological integration of natural resource development. The most tangible expression of institutional patterns is the codification of social norms in law. Laws reflect cultural perceptions of nature, scarcity, society, and legitimate patterns of social control. By defining relationships among individuals, nature, and society, they allocate resources, constrain patterns of use, provide predictable frames of reference, and mediate conflicts.

In Southeast Asia, as elsewhere in the world, environmental laws are under serious strain. Legal patterns are not congruent with the rapidly changing conditions being created by industrialization, urbanization, agricultural development, and an expanding population. Laws are characteristically fragmented, lacking the uniformity and internal compatibility necessary for ecological development. With the exception of Thailand, all nations in the region possess legal structures that are hybrid legacies of traditional culture and colonial imposition. All Southeast Asian nations lack environmental laws that can accommodate divergent pressures for modernization, nationalism, and the preservation of tradition. How to achieve organic structures that are predictable, effective, and culturally legitimate is an important and difficult question.

The four nation Mekong development program exemplifies the emergent legal problems affecting resource development in Southeast Asia. The cooperative effort raises several major legal issues.

1. Integrated development and management of the basin will require acceptance by the Mekong nations of a common legal mechanism for the reasonable and equitable distribution of mainstream flows. Such a formulation must take quantitative and qualitative aspects of water into consideration. It must merge four different concepts of water rights and four highly complex traditions into one legal framework.

2. The acceptance of a legal basis for the allocation of Mekong water will create the need for adjustments in national water laws. All nations will need to bring their patterns of allocative control into conformity with the basin program.

3. Water quality will be a problem. Upstream industrial, agricultural, and municipal discharges will need to be controlled if they seriously reduce water quality for downstream nations. Legal bases for control of discharges will become increasingly important as the Mekong program proceeds.

4. Mekong development will alter present systems of land law by placing new demands on mechanisms of land allocation and transfer. Land tenure, often discussed in its equity implications, is also important for environmental productivity and stability.

The Mekong Secretariat, although badly limited by lack of resources, already has accomplished much in analyzing legal aspects of its program. It has surveyed water legislation in, and international legal relationships among, the basin countries, proposed a basin charter that defines some fundamental constituents of basin water law, and sponsored the development of national committees assigned to prepare national water policies.

Urban environmental problems are legally similar to those of water quality control in the Mekong basin. They involve interdependent relations among resource users, public and private, and require mediation when such relations become competitive. The definition of rights and obligations, and the assessment of liability for damages, must be determined within the same system of law.

Land tenure effects of the "green revolution" provide a related set of legal problems. New technologies increase optimal sizes of farming units and disparities between economic possibilities of different kinds of land. Both tendencies reduce the stability of existing land tenure patterns and the adequacy of land allocation mechanisms. Adoption of conservation practices is more likely given security of tenure and economic viability. The evolution of land laws is therefore important for sound and productive agricultural management.

The international use of common resources such as fisheries, water, navigation routes, and the seabed illustrates how legal questions in the Mekong basin are part of a broader range of issues in Southeast Asia. The definition of fishing rights has already received substantial legal attention. It is essential before international fishing agreements can be formed and cooperative management of ocean resources attempted. A legal basis for international resource management is also required to cope with environmental consequences of industrialization and urbanization. The increased exploitation of offshore oil and mineral wealth is another growing source of environmental stress on common resources and the laws that organize their use. Effective resource management will depend upon the existence of a legal basis for cooperative action among Southeast Asian nations.

Conflict between colonial and indigenous legal patterns is a significant deterrent to environmental conservation in Indonesia and the Philippines. It imbues both legal systems with an indeterminacy on resource matters, reduces the predictability of legal processes, and undermines the legal security that permits and encourages longer-term investments. The Philippines has not confronted its legal problems. Land wars on Mindanao and Luzon are partially caused by legal ambiguities. Indonesia is attempting to improve its situation but is hindered by the great shortage of professional resources. The present program for training Indonesian lawyers, funded by the Ford Foundation, is valuable and should affect how that nation exploits its forest, mineral, oil, and land resources. Similar possibilities for training programs exist throughout the region.

The Law Association of Asia (LAWASIA) is proving to be a viable institution for legal development in Southeast Asia. It has published one comparative study, Asian Contract Law, and is about to complete a second on Asian credit and security laws. Both books begin to provide a basis for future legal reform and national studies. Development of resource-related courses and training and research programs in university law schools is also important, and possibilities for it are emerging.

Public Education

Effective environmental management must be founded on genuine popular sympathy and understanding for why it is important and how it can be achieved. The most sophisticated management superstructure cannot control resource use without the consent of the people. Because coercion is expensive, popular education becomes crucial for long-term resource development. It is the prime means to weave an ecological ethos into the fabric of culture.

Science instruction at primary and secondary levels of education is important. It develops the analytical view of environment that is essential to perception of causal relationships and to confidence in human abilities to manipulate them. Without such views, people have difficulty understanding why the immediate benefits of today's exploitation should be postponed for a hypothetical future to which they foresee no claim. Science education can begin to generate a sense that natural processes are understandable, predictable, and amenable to some human, even personal, control. That sense is essential if governmental actions for environmental management and population planning are to be effective in the long run.

Ecological perspectives are gradually being incorporated within science curricula in various countries of Southeast Asia. The Science Center of the University of the Philippines and the Institute for Promotion of the Teaching of Science and Technology, Bangkok, have done excellent work in this regard. The "green version" of High School Biology, published by the American Institute of Biological Sciences, is being translated in several countries of the region. Its environmental emphasis and its use of the laboratory facilities nature provides are becoming influential in education circles.

Implications of an environmental perspective for education extend beyond the teaching of natural science. The interdependence of individuals' actions and their effects on other people in the community, although taught in terms of traditional and nationalistic values, have generally not been dealt with in terms of the contemporary world of industrialization, agricultural development, rapid communications and movement, urban and population growth. Relations between population dynamics, resource capabilities, society and technology, in community and nation, offer valuable organizing principles for education in social studies, geography, history, and other subjects directed toward the formation of norms, values, and new social skills.

Mass media are other means of popular education. Radio, television, and newspapers are excellent vehicles for communication with the vast majority of people who live outside the bounds of educational and governmental organizations. While the quality and quantity of newspaper reporting on environmental issues have been increasing markedly, radio, television, and film have received little attention for their possibilities to increase public awareness and knowledge. Studies in northeastern Thailand have demonstrated the receptiveness of farmers to radio farm reports. Television ownership and film viewing are expanding rapidly. Opportunities to explore these media as sources of effective public information about the environment seem challenging ones.

Finally, environmental interest groups can play important parts in public education. The Malayan Nature Society, Siam Society, Philippine Society for Better Environment, and the Society for Conservation of National Treasures and Environment are groups which have proven particularly vital in raising issues, enlightening the public about them, and proposing better approaches to their management. Other environmental associations are springing up on university campuses and in cities throughout Southeast Asia. Their projects, exhibits, seminars, and public statements are serving to heighten public awareness and influence the content of media coverage and governmental programs.

Professional Coordination and Communication

The development of institutional aspects of environmental management must have a local base. Imported ideas are likely to be irrelevant to Southeast Asian situations. Suitable approaches must be rooted in the virtues of local outlook and knowledge. They must be formed by people who understand the strengths and weaknesses of their systems and can cooperate with one another to find better means of utilizing them.

The need for improved communications among Southeast Asian professionals is apparent. At the present time, many in the fields of environmental sciences, management and policy operate in isolation, unable to benefit from the ideas and skills of their peers or to achieve public influence commensurate with their knowledge. Professional conferences in a number of fields, held nationally and internationally, have helped to increase collective capacity to define issues and approaches, but the needs and opportunities continue to be large.

Facilities for publication of scientific work in the region are as yet inadequate to encourage professional communication and incentives for scientific work. Many journals established during colonial times, some excellent, have declined or disappeared. They or their replacements may come to life again when there is a strong enough scientific community to support them. Conversely, they have an important role in strengthening such a community. The absence of generalized scientific journals in Southeast Asia also is significant. Journals like Science, Nature, New Scientist, Scientific American, and Environment have fostered much of the awareness of ecological problems in the West. Such Western journals have little circulation in Southeast Asia, and there are no local equivalents.

A basic problem of professional development and communication has been the sense of frustration common to all young professionals in Southeast Asia. Agencies that send students abroad for advanced training and then assume their mission is accomplished when a degree is granted must realize the importance of satisfying the professional expectations of the returnees. Western concepts and expertise acquired during study abroad, as put forth in research proposals by these young professionals, are often ignored by Southeast Asian governments and universities--to the long-range detriment of the region and the individual professional alike.

Some Innovative Programs

Terrestrial Ecology and Resource Management

Strengthening environmental management in Southeast Asia depends, to a great extent, on increasing the flow of new ideas and techniques. Contemporary Southeast Asia is not conducive to scientific innovation. Nevertheless, many talented scientists advance their work by unusual ability, energy, dedication, and leadership. With additional support, they can contribute much to national development. In this section, we mention some organizations, research and training programs that are present and potential sources of environmental innovation.

Centers of Research and Training

Bogor, Indonesia. Bogor is one of the great world centers of tropical biology. It contains a wealth of scientific talent dispersed among its numerous institutes and centers, and has a long history of achievement and excellence. Scientists there have the potential for a cohesive community.

Perhaps the best-known center of tropical studies in Bogor is the National Biological Institute (NBI), which includes the National Herbarium, Zoological Museum, Botanical Gardens, and Treub Biological Laboratory. Its reputation rests, to a considerable extent, on its high standards of taxonomic biology. The herbarium collection is the finest in the tropical world. It is used as a basis for the Indonesian-Dutch *Flora Malesiana*, a multi-volume project describing and classifying the flora of Southeast Asia. A large proportion of this flora, much still unknown and possessing potential economic value as a source of new crops and genetic materials, will have disappeared by the end of the century because of forestry and agricultural development.

Attached to the NBI is the Institute for Tropical Biology (BIOTROP), established by the Southeast Asian Ministers of Education Organization in 1967 as a regional center for ecological training and research. BIOTROP has outlined ambitious programs in forest and pest ecology and is currently sponsoring studies of *Imperata* management. It has given many graduate training courses, has hosted an international conference on management of lowland tropical forests, and has attracted a number of foreign biologists to Bogor for research and teaching. It is also establishing a field station in the rain forests of East Kalimantan.

BIOTROP uses the staffs of the NBI, the Forest Research Institute (FRI), and other Bogor organizations to implement its programs. The Forest Research Institute has traditionally concentrated its studies on forest plantation problems in Java, but is now being drawn toward rain forest management research on Kalimantan. This is important because of the rapid exploitation of Kalimantan and the dearth of current knowledge about Indonesian rain forest management.

The Institute of Agriculture, the national agriculture university in Bogor, is displaying increased interest in ecological aspects of development. A group including agronomists, statisticians, fisheries biologists, and foresters is running an interdisciplinary teaching program emphasizing systems concepts and quantitative techniques. The program will be strengthened by a research station in southeastern Sumatra devoted to studies of agricultural management systems in recently logged coastal areas. It is a potential complement to the programs of BIOTROP, the forest and agricultural research institutes, and government agencies working on coastal development.

Bogor faces serious difficulties that must be overcome if it is to emerge as a center for ecological studies. It is still captive of the taxonomic tradition. Its scientists have difficulty in finding the time and resources to devote to concentrated research efforts; this reflects a crucial scarcity in manpower. Its broad, problem-oriented programs in forest and coastal ecology and management, the specialized capacities of its scientists, and the lack of ecologists to mesh broad purposes with specialized capacities, are breeding frustrations among creative people who have much to offer when given the support to work out their ideas. The promise of Bogor is real; its problems should recede before it.

The University of Malaya Ecology Unit. The University of Malaya offers the only degree in ecology in Southeast Asia. Its Ecology Unit is pursuing comprehensive studies in rainforest, lake, and estuarine ecosystems. The unit is within the School of Biological Sciences and draws upon the abundant staff of the school for teaching and research. In turn, it organizes and coordinates integrative research activities and affords staff of the school opportunities for collaborative work. This arrangement has supported two ecosystem studies that are models of interdisciplinary coordination and promise to yield information and insights of international significance. One is of a rainforest reserve near Pasoh. The other is of Tasek Bera, an expansive lake-centered system in southwestern Pahang. Both are parts of the International Biological Program and are linked to related studies in other nations.

Members of the unit have also begun a third ecosystem study of coastal mangrove swamps. The importance of mangrove areas to ocean fisheries and coastal agriculture, their vulnerability to effects of development, their extensive distribution throughout Southeast Asia, and the lack of knowledge about them, suggest the study's potential value.

The Kasetsart University School of Forestry. The School of Forestry pursues an active program of upland ecosystem research. Staff members have studied the ecology of several forest types at the Sakaerat Experiment Station in the northeast of Thailand. Productivity studies of tropical dry evergreen forest systems complement the Malaysian research at Pasoh. The school also operates a watershed research station in the hills north of Chiengmai yielding watershed management information of substantial value. Staff members of the school interested in hill agricultural problems have conducted some excellent studies of the ecology of shifting cultivation in the North. A team is now beginning to map ecosystem capabilities in parts of that region.

The school is a vital research organization and its ambitious staff development program will increase its strength. Unfortunately, it will probably lose its Sakaerat site because of the withdrawal of funds and the inexorable encroachment of agriculture into the forest.

University of the Philippines, Los Banos Campus. The University of the Philippines has strong and vigorous Colleges of Agriculture and Forestry at its Los Banos campus about forty miles southeast of Manila. Located at an intersection of mountain forest, lowland agriculture, and urbanizing areas, it has access to excellent and diversified sites for ecological research. The dominant source of resource managers in the Philippines, it also trains people from other nations in Southeast Asia. Although no formal interest in ecology has emerged, many staff members are working on resource management problems.

Studies of grassland ecology and management are beginning and should provide a valuable link between concepts of forest and agricultural management. Agriculturalists, who have tended to concentrate on specialized problems, are gradually shifting toward a broad perspective of cultivation systems. Recent difficulties with control of insects and diseases on high-yielding grain varieties by conventional techniques have encouraged this shift. Designing cropping systems that reduce insect damage is one approach being attempted. Because of its basic strength and its tradition of pragmatic response to need, the Los Banos campus seems likely to emerge as a center in Southeast Asia for ecological studies of agricultural systems.

Multiple Cropping: Chiengmai University and the International Rice Research Institute

Projects at Chiengmai and IRRI demonstrate the technical feasibility of a number of multiple-cropping systems. Examination of their economic and social viability has begun and should reveal some of the many problems in management, marketing, finance, and extension that will affect their acceptance. The Chiengmai and IRRI projects are taking tentative first steps along a path of innovation that stretches far into the future.

Many basic agro-ecological questions remain. What structures, compositions, and temporal variations of crop cover will most efficiently convert solar energy to food and fiber? How will they affect soil structure and fertility, moisture regime, and pest, disease, and other conditions of biotic balance within the crop canopy? Which systems have the greatest capacities for internal maintenance and stability? What are the characteristics that make them so? What cultural, chemical, and mechanical techniques will be most appropriate for management of sophisticated systems and for the maintenance of general environmental stability and productivity? What kinds of systems will be needed in environments other than those now being studied? How can multiple-cropping concepts be applied in a wide variety of agricultural situations?

These and similarly complex questions will not be answered for a long while. Fortunately, other research stations throughout Southeast Asia are developing multiple-cropping components and individuals are doing related studies in stations, institutes, agencies, and universities across the region. If interaction and communication are improved, the total stock of experience should begin to evolve strategies of innovation and a beneficial division of labor.

Pest Ecology

Pest ecology is an important field for research and training in Southeast Asia not just because pests are major problems and pesticides can produce adverse side effects, but primarily because significant opportunities for innovation exist. Ecologists can now develop approaches to pest control that are effective, safe, and specific. As mentioned, such approaches have been used successfully in Malaysia. Continued progress, however, requires people who can define pest problems in ecosystem concepts and attack them using specialized knowledge of environmental processes. Entomologists with this training are scarce.

BIOTROP, the University of the Philippines, and IRRI are supporting studies of pest ecology. The Malaysian Institute of Medical Research and the Regional Institute for Tropical Medicine, centered in Bangkok, do much of the work in the region on the ecology of human disease. The Malaysian Agricultural Research and Development Institute (MARDI) may eventually assume a leading role in integrated pest control research.

Marine Ecology and Resource Management

The management of ocean resources has not received the attention it requires in Southeast Asia. One of the more promising situations is in Bangkok with the marine ecologists at Chulalongkorn University, the Department of Fisheries' Marine Fisheries Laboratory and its field station at Phuket. Ecology courses at Chulalongkorn draw large classes of undergraduates in general biology, marine sciences, and education who are provided high caliber teaching and abundant field experience on the Gulf of Thailand. A number of students have been attracted to graduate work in ecology and benefit from the enthusiasm and interest of the staff.

Relations between the Chulalongkorn program and the Marine Fisheries Laboratory are close. Experts from the laboratory teach several courses. The laboratory provides opportunities, supervision, and support for student research, and also hires many graduates. Development of the Phuket Station, which seems destined to become a significant source of marine knowledge in Southeast Asia, is progressing rapidly and should further strengthen these productive links between professional training, research, and management applications.

Waste Utilization Technology

Pollution problems result when unusable substances are discharged into the environment. One approach to solving them is to find productive uses for "waste." Another is to design modes of waste capture. A third is to reduce the amounts of waste from a production process by increasing its efficiency. All three offer opportunities for innovation that researchers in Southeast Asia have begun to explore.

A traditional means of sewage disposal has been to collect night soil for use as fertilizer for crops and fish ponds. Staff at the Asian Institute of Technology and the Applied Scientific Research Corporation of Thailand are developing a modern urban version of the system. Sewage is pumped into a series of ponds where it undergoes rapid oxidation. Algae thrive in the rich pond environment, designed and controlled for optimal growth. The algae can be harvested, dried, and sold as high-protein poultry or pig food, or transferred to adjacent ponds for fish production. The products of the system are food and pure water. The concept seems ideal for tropical situations where abundant sunlight is available to energize the process and markets exist for the end products.

Beneficial conversion of wastes from agricultural processing plants is another area of interest to scientists in Southeast Asia. Such wastes, when discharged into rivers and bays, deplete oxygen concentrations, reduce capacities for self-purification, and lower the quality of the aquatic habitat and fisheries. At the University of Malaya, efforts are underway to convert tapioca wastes to starch to be used industrially or as the basis for protein-producing fermentation. At the University of the Philippines College of Engineering, means of utilizing coconut wastes are being sought. Wood, oil palm, rubber, and sugar processing wastes are also receiving attention.

Solid wastes are potentially useful resources given appropriate technologies. The Bangkok Municipality is attempting to use garbage in fertilizer production and electricity generation. Singapore compacts it and uses it for landfill. Sugar pulp is being considered as a source of fiber for paper production. Pineapple pulp has proved a valuable feed for livestock. Rice chaff is being tested in filtration processes, rice stalks and plastics manufacture.

Current efforts to increase the efficiency of rubber, oil palm, and coconut processing activities, and to diversify their products, are also yielding economic benefits while reducing environmental strains. Substances once discharged as waste now emerge from the factory as saleable commodities. Materials once assigned low grades have risen in value with the development of new products that require them.

While the list of achievements may seem significant, it represents just the surface of possibilities in the region. The opportunities and needs for "tropical technologies" are great. Innovation of this kind is still isolated. How to stimulate it is a challenging question significant for economic development and the quality of life in Southeast Asia.

Information

Our list of innovative activities is much too brief to be complete. Many individuals are doing valuable work outside of the organizations we have mentioned. Numerous government and university research groups have not received the notice they deserve. Some active fields, such as inland fisheries research, have not been included. These omissions reflect, in part, the limitations of our time and knowledge.

They also reflect something more basic to issues of environmental management in Southeast Asia: the difficulty of obtaining information that does exist but is not available beyond its source. People and organizations working on similar problems are often unaware of one another. One nation or agency may have developed useful methods, ideas, or bodies of data. Another, not knowing they exist, will begin an independent search that may take years of effort. The severe dispersion of information is counterproductive, costly, and adverse in its effects on resource development. Mechanisms to overcome it are probably among the most crucial subjects for innovative thought.

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